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ABSTRACT

This is a summary of findings of three studies of learning style in computer-assisted instructional (CAI) settings. In study one, learning style and math achievement data collected from an intact class of 23 seventh and eighth graders indicate that students' learning style preference changed after four months of CAI towards the accommodator type. Students with high math ability showed a higher pre to post learning style shift than the low ability students. In study two, learning style and math achievement data collected from a group of 22 19- to 21-year-old disadvantaged students involved in a five-week program of computer-assisted remediation showed a shift towards the accommodator type comparable to the results of study one. In study three, learning style and classroom achievement of a group of 30 adult graduate education majors in a course that deals with utilizing microcomputers in education (Apple IIe) shifted after five weeks towards a preference for more concrete experience and more reflective observation. It is suggested that a change in student learning style preference, particularly for high ability students, occurs in CAI environments. A shift towards concrete experience and active experimentation may relate to higher math achievement in similar CAI environments.
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Learning Style Shifts in Computer-Assisted Instructional Settings

by

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A paper presented at the Annual Meeting of
the International Association for Computers in Education (IACE)
held in conjunction with
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RUNNING HEAD: LEARNING STYLE SHIFTS

Learning Style Shifts in Computer-Assisted Instructional Settings

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Abstract

This is a summary of findings of three studies of learning style in computer-assisted instructional (CAI) settings. In study one, learning style and math achievement data collected from an intact class of 23 seventh and eighth graders indicate that students' learning style preference (Kolb's LSI, 1976) changed after four months of computer-assisted instruction (WICAT) towards the accommodator type. Students with high math ability showed a higher pre to post learning style shift than the low ability students. A multiple $r=.90$, $p=.0000$ was obtained for the dependent variable math posttest achievement correlated with math pretest and LSI concrete experience(CE).

In study two, learning style and math achievement data collected from a group of 22 nineteen to twenty-one year old disadvantaged students involved in a five week program of computer-assisted remediation (WICAT) showed a shift towards the accommodator type comparable to the results of study 1. The active experimentation (AE) dimension correlated with course midterm grades with $r=.45$, $p=.035$.

In study three, learning style and classroom achievement of a group of 30 adult graduate education majors in a course that deals with utilizing microcomputers in education (Apple IIe) shifted after five weeks towards a preference for more concrete experience and more reflective observation. The active experimentation (AE) dimension correlated with course midterm grades with $r=.38$, $p=.037$.

Though causal inference is problematic due to instrumentation and design, it is possible that a change in student learning style preference, particularly for high ability students, occurs in CAI environments. A shift towards concrete experience (CE) and active experimentation (AE) may relate to higher math achievement in similar CAI environments. Future studies of learning style preference should include both Pre and Post measures.

Learning Style Shifts in Computer-Assisted Instructional Settings

Studies of learning style preference and achievement may provide some guiding principles for developing truly individualized computer-assisted instruction. This position is generally accepted for several reasons: matching instruction to learning style is thought to be efficacious; learning style data may provide additional instructional options; and learning style accounts for part of the individual's idiosyncratic response to instruction.

First, matching the instructional method to a student's preferred learning style should increase the efficiency of the learner in that learning situation (Stice and Dunn, 1985). There is research to support this position but no general model exists to explain this "matching" principle, though it is intuitively appealing. Matching instructional method with student learning style preference may reduce ambiguity, thus simplifying the cognitive demands on the student. Also, motivation or interest would be important since learning style preference is in fact an attitude.

More research with learning style measures would result in increased awareness of additional instructional delivery options by instructional developers. Designers of individualized instruction should take into account the many student variables that fall into two categories, immediate variables and historic or past variables.

The immediate variables currently in use in CAI settings include mostly content or process questions that are digital in nature. Immediate variables are digital in that they are in a yes/ no, on/ off form. When immediate variables are answered correctly, the student is sent forward to the next frame. If the student answers incorrectly, the student is sent back to some type of remediation. Some attempts to use immediate variables for determining learner appropriate levels of feedback include contingent feedback (Alessi & Trollip, 1985; Gilman, 1969), attribute isolation feedback, and various learner control methods (Carrier and Sales, 1987). Immediate variables alone provide less information about the subtle range of branching options that could be offered in CAI than could a combination of immediate and historic variables.

Historic variables, like learning style preference, locus of control, and need for achievement (Grabinger & Jonassen, 1988), would be more analogic in nature and so can possibly provide this subtle information. For example, in a lesson on how a bill becomes a law, the CAI lesson may present the main ideas as a tutorial which require the student to read and think about the information. Several practice items or

comprehension questions relating to the topic could then be asked. If these immediate variables show that the student has not grasped the concept, then historic information like learning style preference could be used to determine the most individualized branching option for that student. If this student learns best by observation, a video clip of a legislature in action could be shown. If this student learns best by doing, then an interactive simulation could be used. This would provide individualization precisely where it is most needed by the individual and in the form or format most closely aligned with his learning style. By considering both immediate variables and historic variables, instructional designers would have available an increased variety of prescriptive branching options.

Even if there existed a perfect measure of learning style, an individual's learning style probably accounts for only a small portion of the explained variance associated with achievement. This small portion, however, may be critical for less able learners. A comprehensive theory of instruction should be inclusive. Additional research with learning styles may clarify some deeper basic issues and may also provide some surprises and insights.

Learning Style and Instruction

Learning style has been defined by Keefe (1979) as "the characteristic behaviors of learners that serve as relatively stable indicators of how they perceive, interact with, and respond to the learning environment." There are numerous learning style inventories available, each based on a particular cognitive viewpoint. Older learning style measures include Kolb's (LSI), Dunn, Dunn, and Price's (LSI), Canfield and Lafferty's (LSI), Hill's Cognitive Style Interest Inventory (CSII), and Gregoric's Transaction Ability Inventory (TAI) (Dunn and DeBello, 1981). Some studies comparing these various instruments have been conducted (Thompson, Finkler, and Walker, 1979). For some learning style measures, internal validity and reliability have been considered (Sewall, 1986, Freedman and Stumph, 1978, 1980, Geller, 1979). Generally, the learning style constructs are diverse from each other and no attempts to integrate several into a generic theory of learning style were found in the literature. Additionally, problems with instrumentation may preclude such integration. The National Association of Secondary School Principals (NASSP) has devoted much attention to this topic and has developed a broadly-based instrument which will probably generate considerable research (Keefe and Monk, 1987).

Learning style may or may not be relatively stable. Humans are adaptable. An

individual changes self to fit the environment and also changes the environment to fit the self. Accommodation is the term used to describe the fitting of the internal cognitive processes to the environment while assimilation is taking in that part of the environment which already fits the internal process. Assimilation would occur when the teaching method matches the learning style. Accommodation would occur if the learner changes learning style to fit the teaching method. It seems logical to assume that both occur, although some learners are more able to adapt than others.

Experience suggests that low ability students would probably be least able to adapt to a non-preferred instructional method and so would benefit most from matching instruction to preferred learning style. High ability learners may be more able to accommodate to different instructional methods. Using high ability students (like college students) in research studies involving matching instruction to learning style would produce many no result conclusions since these students are expected to be more able to accommodate or adapt to instructional methods. However, learning style may interact with level of challenge so that even the most able students will benefit from matching instruction to learning style if the lesson content is new or difficult.

Matching instruction to preferred learning style assumes that both preferred learning style and instructional method can be adequately identified and then be adjusted to correspond. The major purpose of this study was to identify a correspondence between learning style preference and a specific form of computer-assisted instruction. Two approaches were used, one analytical, the other empirical.

The analytical approach

The analytical approach seeks a correspondence between instruction and learning style by examining the logical consequences on student cognition of the presentation mode of a specific instructional application in a CAI setting.

The computer lessons were delivered on a WICAT learning system. A typical lesson had the following components: an advance organizer, a tutorial teaching lesson, practice, and a posttest. The branching and remediation for each student varied based upon immediate variables, so that each student saw slightly different lessons. From an individual student's viewpoint, the lesson was highly linear.

Contrasting learning from print (the current traditional method of instruction) with CAI will provide a base line for further comments. Walter Ong (1984) has noted that print, by its nature, is linear. Text is arranged in precise rows of words, each unit

or sentence conveying a meaning, with meaning following meaning linearly.

In print formats, having many sentences grouped together into paragraphs of related sentences with related meanings allows the learner not only to process or consider the meaning of one unit but also to develop a gestalt for the total meaning conveyed through the paragraph and the page (Gillingham, 1988). Turning a print page becomes a physical closure under the control of the learner. Further, back-paging is easy so a conceptual link can readily be formed between what comes next (the following page) and what has been covered (the previous page). Meaning follows meaning in a linear fashion, but within the broad context of many other meanings.

Similarly but more emphatically, CAI text tends to achieve closure after each screen. Each screen tends to contain only one or a few "meaningful units" and a substantial amount of time is usually required for one screen to clear and the next screen to appear. Each screen and its meanings associate with only two or three previous screens due to memory load (Gillingham, 1988), time, and closure. The actual content of this meaningful unit (Kintsch, 1986) held in working memory may equal about one good paragraph if it were print. This process overemphasizes the linear connection of meaningful units because these units are immediate and time associated.

Also, there is an increase in transition time between segments. The eye can scan a print page at the speed of thought, perhaps relocating a previously read sentence on the same page in about 300ms to 500ms, which allows almost immediate access to such sentences for comparisons and evaluation. In contrast, CAI may require at least 1 to 3 seconds to clear and replace previous text. This combined with less information per screen compared to print significantly alters the students' cognitive review process (Bevan, 1979). Not only more time, but also more effort is required to back-page in CAI and so the learner may avoid making immediate comparisons of the just read text which may be critical in discriminating the meaning of the text sequence. The thought itself, or the motivation to compare the thought to previous text, may be lost due to this long transition time between segments.

The rhythm in processing text in CAI then will be different from processing printed text in several regards. As mentioned above, the general discrimination or comparison strategies required for deep or difficult passages of CAI text may be subverted due to a lack of overall organization or gestalt. The macro-level gestalt may also be subverted. In contrast, printed text has a "feel" to it. The student can

pick it up, leaf through the pages and hear them crackle, and can feel the weight of the text. The student can easily check chapter divisions or other milestones, check page numbers, and generally develop a feel for the cycle or rhythm of the necessary mental investment of effort required for the learning. CAI usually lacks most of these features. The learner, of necessity, must accept the new lesson somewhat unprepared both in years of experience with this format and from being able to pre-examine it before reading. Every moment in the CAI lesson becomes immediate. The current moment becomes more important than what came before or what will come after. The rate of the passage of time seems to change. In this way, CAI lessons alter the traditional rhythm of learning, shifting the learners' attention towards the immediate.

Learners in this type of CAI environment may tend to change to fit this environment. The emphasis on the immediate and the general non-critical acceptance of meaning segments would encourage intuitive decision making. The tendency to guess the responses to questions in a trial-and-error manner would increase and probably be rewarded. This would increase risk-taking behaviors. A tendency to push on or forge ahead would develop. There would probably be less reflection and more action; learners would be less passive and more active. Rather than pondering at length on a screen, as we sometimes tend to do with difficult print text, a learner with a CAI-developed learning style would press return and hope the meaning would eventually become evident. Back-paging would occur infrequently.

The amount of abstraction in the lesson would be dependent on the lesson content rather than the lesson presentation process and so any possible learning style shift towards abstraction in a CAI environment would be irregular or unpredictable because some lessons are abstract and some are not.

CAI lessons usually encourage a one right answer set which might be referred to as "converging" on the answer. The WICAT lessons allow for a broad range of possible correct answers, thus diluting this one right answer set and any tendency to converge.

These learning style changes may be reasoned, but could these be measured?

The empirical approach

The empirical approach requires a measure of learning style. For purposes of these studies, it should correspond to the description of learning style type developed above. As mentioned, numerous learning style inventories are in use. Kolb's

LSI was selected for this study due to its focus on thought processing variables that fit expectations about learning style type with this particular CAI learning system. Its popular acceptance and ease of use were also desirable factors.

Kolb's LSI considers four types that are described based upon two bipolar dimensions. The four types are accommodator, diverger, converger, and assimilator. The two bipolar dimensions are abstract conceptualization (AC) versus concrete experience (CE), and reflective observation (RO) versus active experimentation (AE). Accommodators and convergers are active learners and correspond to the expected CAI learning type described above. Divergers and assimilators are passive and reflective unlike the expected CAI learning type. The abstract/ concrete bipolar dimension seems less related to the described CAI learning type. A CAI lesson that emphasizes a one right answer set would correspond to the converger type.

The diverger type has been shown to be the primary type for educators (Kolb, 1979). In a traditional classroom, if students have adapted to the teacher's style, we could expect students on the average to be divergers. In an intense CAI environment with lessons like those described above, we might expect learners to be accommodators or convergers on the average.

We emphasize at this point that not all CAI is like that described above, although many CAI lessons do fit these descriptions. Other forms of CAI might encourage the development of other learning style types. For example, assimilators might do well with computer simulations that require the interpretation of data and the development of models to explain this data. Confounding of research involving learning style preference in CAI environments could easily occur since it is not necessarily the media, but rather the form of the lesson that determines the relationship between learning style and learning process.

Kolb's LSI has been used to show relationships between learning style preference and some educational and career activities. Problems with the reliability of the instrument have been reported (Lamb and Certo, 1978, Geiler; 1979), and low reliability hinders the predictive conclusions that can be reached. However, the correspondence between the expected learning style type and Kolb's style types, the face validity of the instrument, and the underlying theory of experiential learning on which it is based is sufficient to justify its use.

This study will attempt to answer the following questions: Do students entering a CAI environment show a change in their learning style preference (attitude)? Do any of Kolb's LSI measures relate to achievement in a CAI environment?

Study 1

The sample consisted of 23 students in one intact combined class of 7th and 8th graders. Pretest math scores indicated that the students were average in achievement. There were ten boys and thirteen girls.

Learning style preference data (LSI, Kolb 1976) and math achievement data (Iowa Test of Basic Skills, ITBS) were collected in October before the WICAT learning system was started in the school, and then again in February (LSI) and March (ITBS). The students received approximately 30 minutes of CAI math instruction per day, three days per week. Additionally the students received 30 minutes per day of either reading or language arts CAI for the remaining two days of the week. This amounted to about 30 hours of math CAI and 20 hours of other CAI instruction during the five month period from October to February.

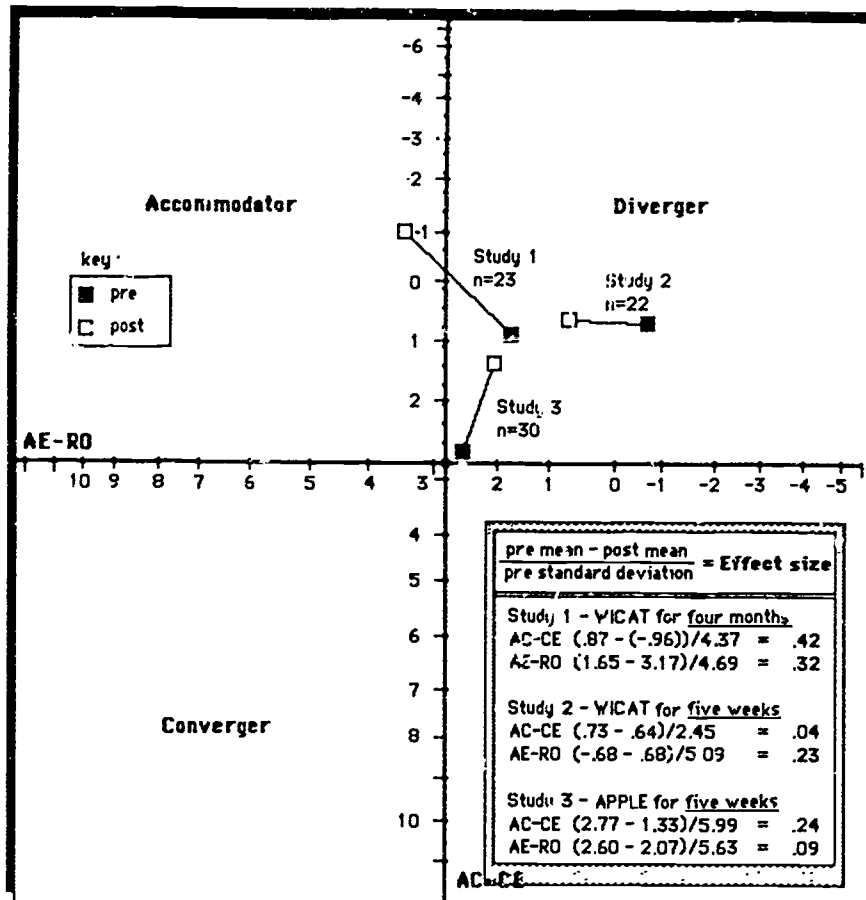
Study 1 results

In a stepwise multiple regression (SPSSx) of all variables with posttest ITBS math as the dependent variable, pretest ITBS math entered the equation first as expected. Pretest ITBS at this step was significant at the $p=.0000$ level with a multiple $r=.75$. The February concrete experience (CE) dimension of the LSI entered the equation at step 2 and was significant at the $p=.0001$ and $\beta=.5$. The resulting multiple $r=.90$ for the two variables preITBS and CE were significant at the $t=.0000$ level and together accounted for 81% of the variance in posttest Math achievement. No other variables entered the equation, p limit set at $\alpha=.05$. Higher preITBS and higher CE resulted in higher math achievement. The following equation was derived from this data: $Y = -17.47143 + .95355(\text{preITBS}) + 2.13486(\text{CE})$. By entering preITBS math into the regression first, the variance of previous math achievement is controlled for, allowing the effects of learning style on achievement to be more easily detected.

The zero correlation matrix showed a strong relationship between pretest and posttest ITBS math scores as would be expected. None of the LSI measures related significantly to postITBS math achievement scores though the February LSI dimensions of CE and RO showed some relation. The negative correlations found between the bipolar dimensions of Kolb's LSI lend some support for Kolb's experiential learning theory, though this may be due to the bias of the LSI instrument (Freedman and Stumph, 1980).

Comparing October and February LSI AC-CE and AE-RO group average

Figure 1.
Relative directions and effect sizes for the three studies.



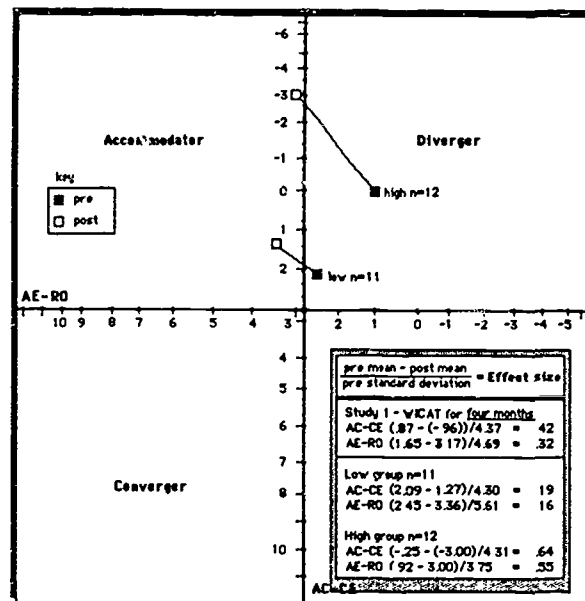
scores showed an interesting shift from the diverger type to the accommodator type. A paired t-test of the AC-CE dimension resulted in a $p=.11$. The AE-RO dimension resulted in a $p=.27$. Though not significant, this shift corresponds with the expected shift towards a more active learning style (see figure 1). Interestingly, when this group was blocked by math pre to post gain, the high ability group showed an effect size of .55 on the AE-RO dimension and an effect size of .64 on the AC-CE dimension. The low ability group shifted in the same direction, but not as much (see figures 2 and 5).

Study 2

The sample consisted of 30 nineteen to twenty-one year old students that had left school before graduation. They were involved in a remediation program with Youth Services America. This organization focuses on preparing these individuals for jobs by developing appropriate skills and attitudes. One aspect of this development involves improving math skills. These students received math instruction on a WICAT learning system for about three hours per week for five weeks for a total of

about fifteen hours of CAI. Kolb LSI data were collected at the beginning and at the end of the five week program. Only 22 students completed the program. Eight were hired during the period and the post LSI measures were not available for these students. Math basic skills achievement data were also collected.

Figure 2
Study 1 LSI pre to post changes blocked by math gain scores



Results of Study 2

These students tended to be divergers who preferred reflective observation and concrete experiences. This result is consistent with previous research. The students shifted from pre to post LSI similarly to the students in study 1. A paired t-test resulted in $p=.13$ for the shift from pre to post AE-RO. Unlike study 1, little change occurred for the pre to post AE-RO dimension (see figure 1). This suggests a preference for a more active learning style. When blocked by math test scores into high and low groups, the high group produced the greater shift, effect sizes of .22 for AC-CE dimensions and .40 for the AE-RO dimensions (see figures 3 and 5). The only significant correlate with math achievement was post AE which obtained an $r=.45$, significant at $p=.035$.

Study 3

Subjects were 30 graduate education majors enrolled in a course entitled "Microcomputer's in Education." Most students enrolled in this course were naive

about computers but were interested in learning about microcomputers and how they can be used in the classroom. The classwork required various microcomputer associated activities including disk initialization, learning how to use the Apple disk operating system, entering and running BASIC programs, learning utilities like word processing and data base applications, and also evaluating educational software. Students spent about 2 hours per week with hands-on instruction using Apple II microcomputers and about 1 hour per week in lecture and demonstration. Learning style measures (LSI, Kolb 1976) were taken at week 2 and again 5 weeks later. This represents about 10-15 hours of diverse CAI experience. Course midterm grades were used for forming high and low ability groupings.

Results of Study 3

This group shifted towards less abstract conceptualization and more concrete experience, though not significantly. When blocked into ability groups based on midterm class scores, the high group shifted more than the low group and in a different direction (Figure 4). The low group's shift was similar to the observed shifts in studies one and two towards the accommodator type. The high group shifted towards more concrete experience (CE) like the results observed in study one. However, unlike studies one and two, the high group in study

Figure 3
Study 2 LSI pre to post changes blocked by a math pretest

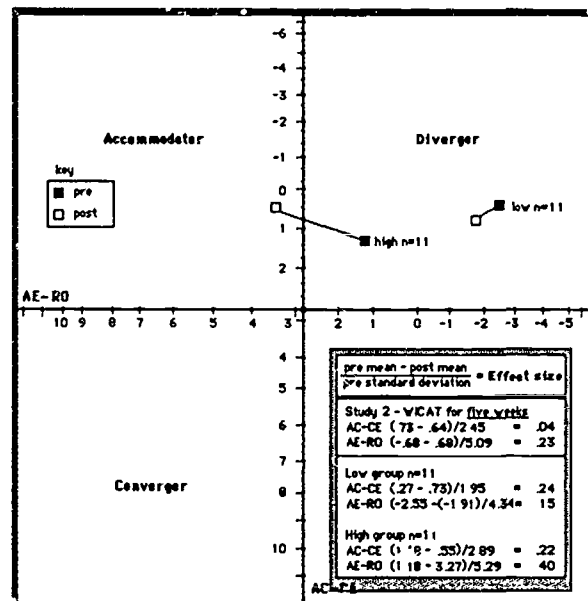
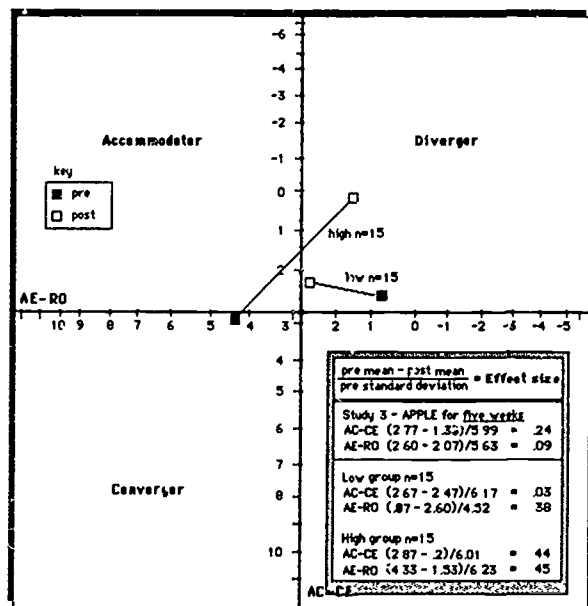


Figure 4
Study 3 LSI pre to post changes blocked by midterm grades



three shifted towards more reflective observation (RO) and less abstract conceptualization (AC) and active experimentation (AE).

The only correlates with achievement were the February active experimentation (AE) dimension, with $r=.38$ significant at $p=.037$. Students that

had a higher active ex-

perimentation (AE) preference at week two of the class tended to do better on the midterm examinations but then these same students preference for AE decreased and their preference for RO increased by week seven.

A summary of the effect size of the pre to post LSI observations showed that the high groups consistently produced considerably greater effect sizes than the low groups except for the AC-CE dimension in study two. Also, study one, which lasted for four months showed larger effect sizes than studies two and three which both ran for five weeks. (See figure 5.)

Figure 5.
Summary of effect sizes.

	Study 1	Study 2	Study 3
AC-CE low groups	.19	.24	.03
AC-CE high groups	.64	.22	.44
AE-RO low groups	.16	.15	.38
AE-RO high groups	.55	.40	.45

Conclusions

The design of the study and low reliability of the instrumentation severely limit causal interpretations; however, the findings of these studies and others suggest that learning style plays a part in learning and should be considered as a design variable.

The math (ITBS) data were taken after a school year of CAI instruction and the LSI data were taken before and during the school year. The correlation occurred between the later LSI measures and not with those before the students started the CAI system. The observed changes in learning style and math achievement occurred together. The extensive CAI provided by the introduction of the WICAT system might reasonably be expected to cause a learning style shift as well as achievement gains. A series of LSI posttest only studies of WICAT schools already existing compared to schools with traditional instruction should confirm or reject any learning

style preference shifts occurring in this CAI environment.

When the learners in studies one, two, and three are separated into low and high ability groupings, uniformly the high ability groups shifted more on the average than the low ability groups. This would suggest that higher ability students adapt to the current learning environment relatively soon and then work more productively in that environment. If so, matching instructional method and learning style preference becomes paramount for low ability students. It seems that the high ability students will learn despite the presentation mode.

Past studies indicate that on the average, students and teachers in our schools can be described as diverger types. Could the introduction of more CAI of this type cause a general average shift towards the accommodator type?

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Figure 1.
Relative directions and effect sizes for the three studies.

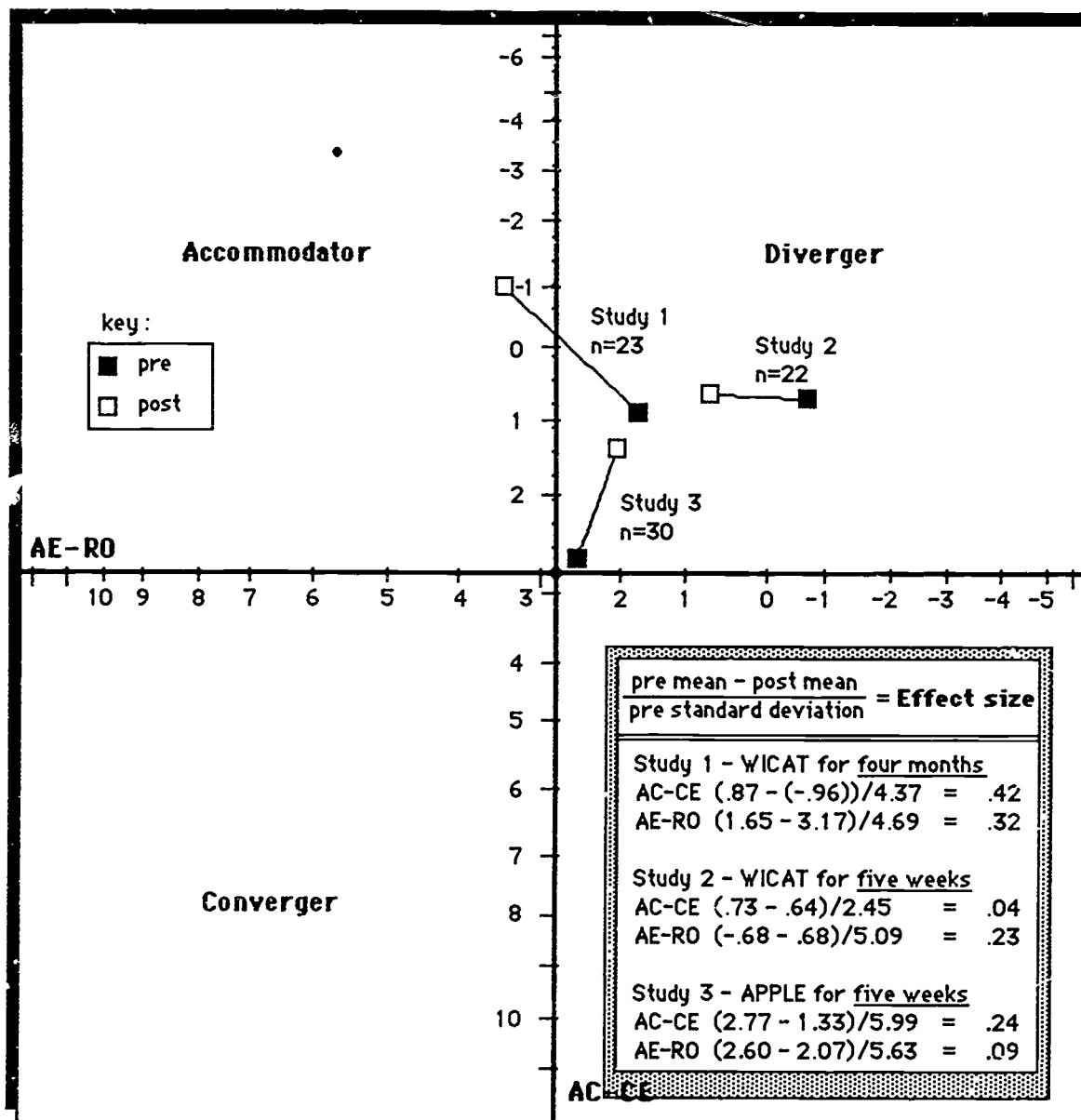


Figure 2.
Study 1 LSI pre to post changes blocked by math gain scores.

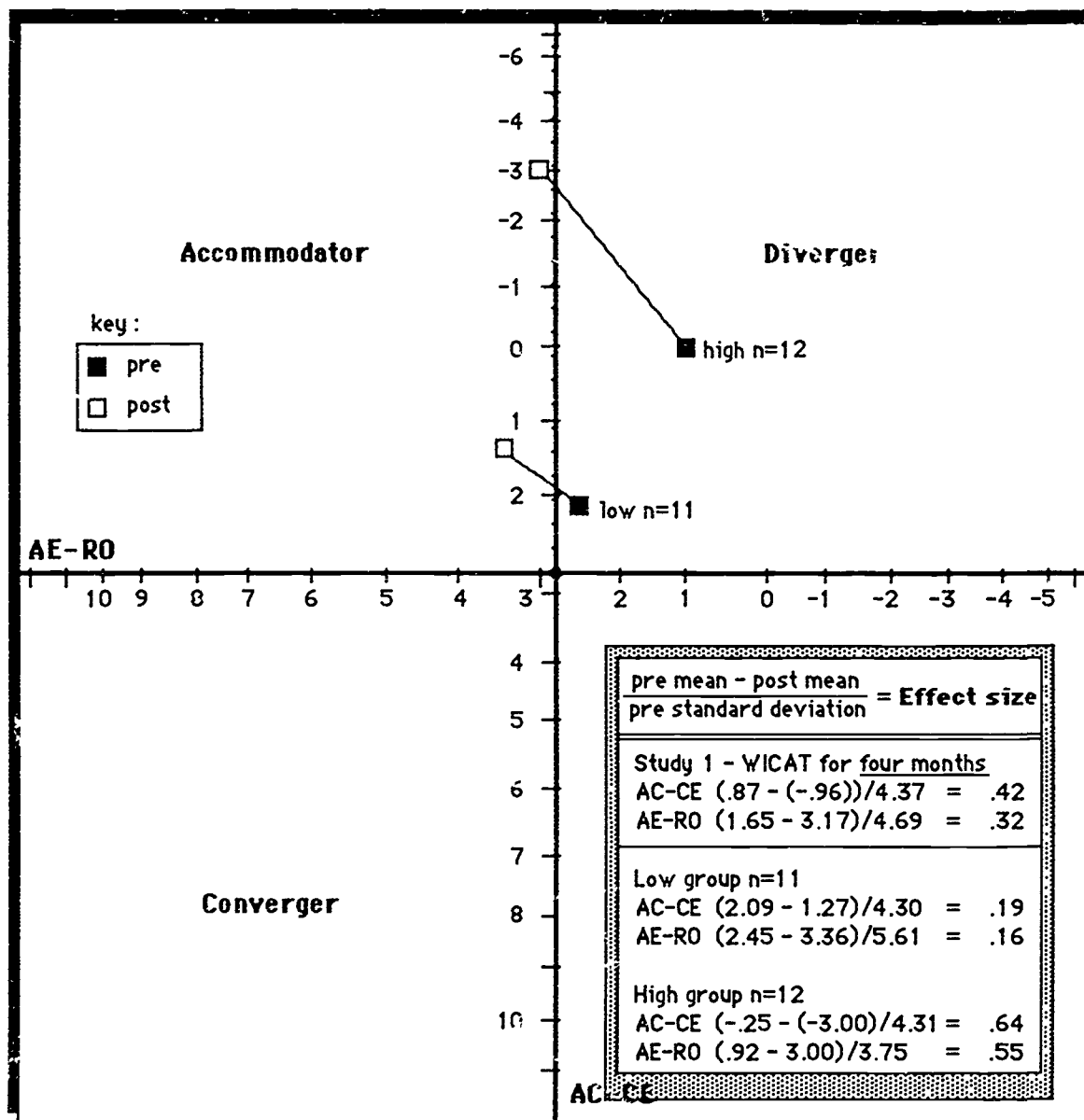


Figure 3.

Study 2 LSI pre to post changes blocked by a math pretest.

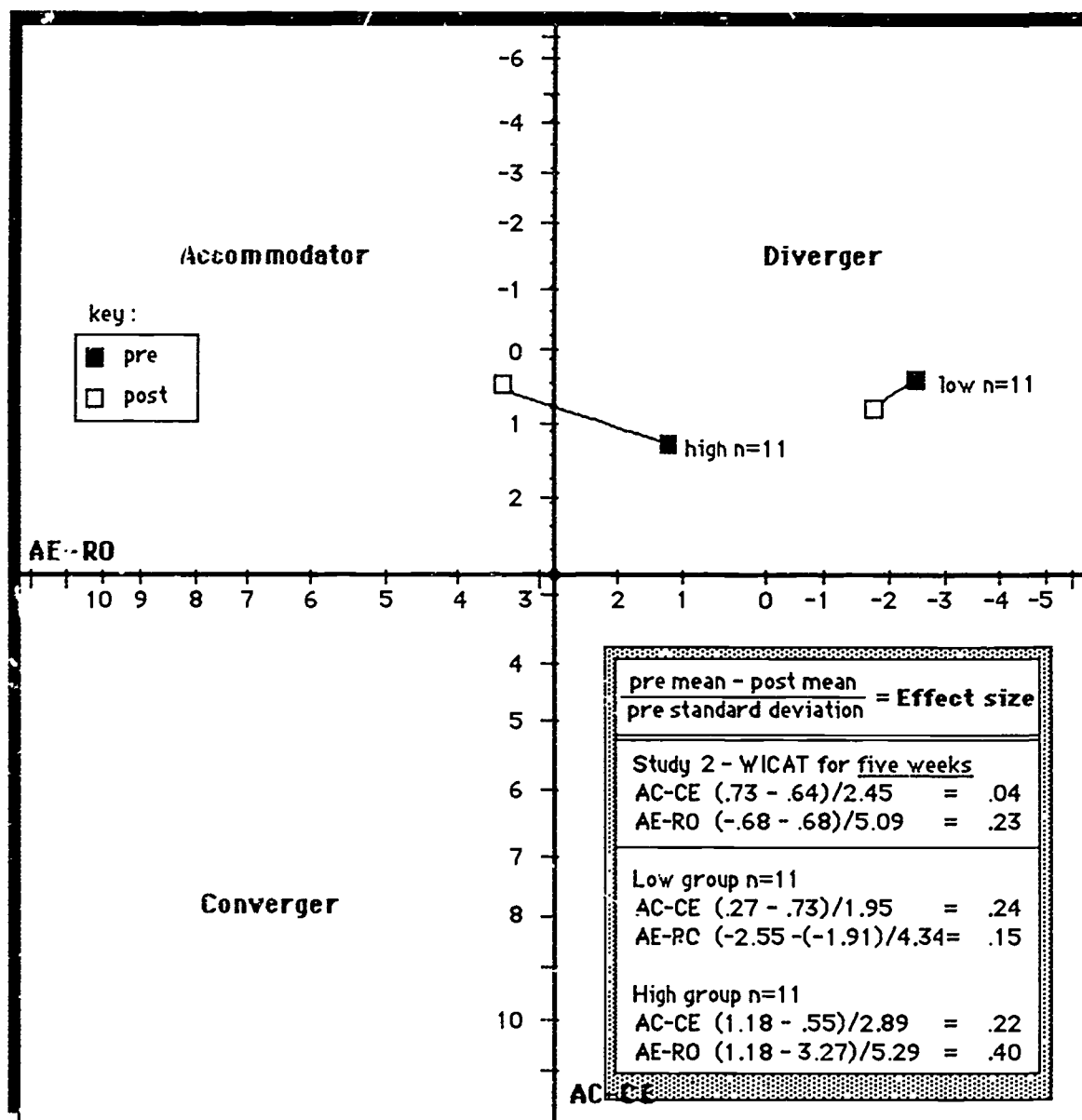


Figure 4.
Study 3 LSI pre to post changes blocked by midterm grades.

